Calcasieu Estuary Remedial Investigation/Feasibility Study (RI/FS): Baseline Ecological Risk Assessment Workshop

Workshop Summary Report

Submitted - October, 2000 - To:

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1.0 Introduction

The Calcasieu Estuary is located in the vicinity of Lake Charles in Calcasieu Parish, Louisiana. The upper Calcasieu River is approximately 15 miles long and includes Lake Charles and the upper Calcasieu River/Shipping Channel down to the Coon Island Loop. Bayou Verdine, approximately 4.2 miles in length, enters the Calcasieu River at the north end of the Coon Island Loop (NOAA 1997). Bayou d'Inde is nine miles long and located to the southwest of Lake Charles. The lower Calcasieu River extends roughly eight miles from Coon Island to the outflow of Moss Lake, and includes Lake Prien, Moss Lake, the Calcasieu Ship Canal, and the old channel of the Calcasieu River.

During the 1950s, much of the Calcasieu River and portions of the various bayous contained within the study area were dredged or rerouted. For example, the southernmost 3,500 feet of the Bayou Verdine were rerouted to the west when Olin Corporation (Olin) built the West Pond over the original bayou. The former route of Bayou Verdine downstream of Interstate Highway 10 was to the east of its present course. Its former confluence with the Calcasieu River-Coon Island Loop is near its present mouth (PRC 1994).

The construction of the Calcasieu Ship Channel in 1941 has altered the salinity regime of the Calcasieu Estuary and impacted marsh areas to the west of Calcasieu Lake. Water control structures were installed by the United States Fish and Wildlife Service (USFWS) to reduce these impacts. Monitoring is currently being conducted by the USFWS to evaluate the effectiveness of these various structures. Additionally, the State of Louisiana has installed breakwaters in the Gulf near Holly Beach to protect the Gulf shore near the Sabine National Wildlife Refuge (SNWR) headquarters. Where interior marshes were destroyed by canal-induced saltwater intrusion, wave-break levees were installed in two open water areas to reduce wind/wave-induced erosion of adjacent marsh shores.

The land surrounding the Calcasieu Estuary includes undeveloped, rural residential, commercial, and heavy industrial property. Heavy industry dominates the southern reaches of Bayous d'Inde and Verdine on both sides. Permitted NPDES discharge outfalls and agricultural and industrial drainage ditches (including the Vista West Ditch, the Faubacher Ditch, and the Kansas City Southern Railroad West Ditch) discharge to the estuary. These discharges (current and historic), stormwater runoff, and accidental spills have contributed to the contamination of surface water, sediment, and biota within the estuary.

The estuary currently supports a recreational fishery, that is primarily targeted on sea trout, redfish, black drum, and flounder. In addition, commercial fisheries for shrimp and crab exist in the southern portions of the estuary, primarily in the ship channel. However, fish consumption advisories have been issued in the estuary to protection human health from adverse effects associated with the ingestion of contaminated fish (LDEQ 1998). Although the estuary is not used as a drinking water source, the surface waters have been designated by Louisiana Department of Environmental Quality (LDEQ) as supporting primary contact recreation, secondary contact recreation, and fish and wildlife propagation (PRC 1994). The Calcasieu Estuary Cooperative Site has not been proposed for inclusion on the National Priorities List (NPL), but has been the subject of numerous environmental studies dating back to the early 1970's.

2.0 Calcasieu Estuary Remedial Investigation/Feasibility Study

The Calcasieu Estuary Remedial Investigation/Feasibility Study (RI/FS) is being conducted to support an ecological risk assessment (ERA) of the Calcasieu Estuary. This ERA is being conducted in accordance with the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessment* (USEPA 1997). The guidance document describes an eight-step process for conducting an ERA, including:

- **Step I:** Screening-Level Preliminary Problem Formulation and Ecological Effects Evaluation;
- **Step 2:** Screening-Level Preliminary Exposure Estimate and Risk Calculation Scientific Management Decision Point (SMDP);
- **Step 3:** Baseline Risk Assessment Problem Formulation SMDP;
- **Step 4:** Study Design and Data Quality Objectives SMDP;
- **Step 5:** Field Verification of Sampling Design SMDP;
- **Step 6:** Site Investigation and Analysis of Exposure and Effects SMDP;
- **Step 7:** Risk Characterization; and,

- **Step 8:** Risk Management SMDP.

In accordance with the USEPA guidance, the Calcasieu Estuary Remedial Investigation/Feasibility Study (RI/FS) is being conducted using a stepwise approach. CDM Federal Programs Corporation (CDM Federal) is the primary contractor for USEPA and has made substantial progress on the initial steps of the investigation. Specifically, the screening-level ecological risk assessment (SERA) has now been completed, including the initial problem formulation, effects evaluation, exposures estimate, and risk calculation. The Phase I sampling program has also been completed, providing detailed information on the nature and extent of contamination. While the results of the Phase I sampling program provide important information for assessing the risks to aquatic and aquatic-dependent receptors associated with environmental contamination, the existing database needs to be augmented to support the baseline ecological risk assessment (BERA). To identify information needs and associated monitoring strategies, the USEPA, Region VI organized a BERA workshop in Lake Charles, LA during September 6 and 7, 2000. The workshop participants included representatives of the National Oceanic and Atmospheric Administration (NOAA), LDEQ, U.S. Fish and Wildlife Service (USFWS) and CDM Federal. The results of this workshop will be used to inform the design of the Phase II and Phase III sampling programs, which are intended to provide information on the bioavailability of environmental contaminants and to fill outstanding data gaps, respectively. This report summarizes the results of the BERA workshop.

3.0 Workshop Goals and Objectives

This workshop was convened to facilitate refinement of the approach that will be used to conduct the baseline ecological risk assessment (BERA) for the Calcasieu Estuary. To support this general workshop goal, a number of workshop objectives were established, including:

- To conduct a site reconnaissance to familiarize the new members of the study team with the Calcasieu Estuary;
- To discuss the overall strategy for conducting the remedial investigation and evaluating remedial options;

- To share technical information on the Calcasieu Estuary, including the location of facilities, the identity of chemicals of concern, the location of hot spots, the ecology of the study area, and prevailing environmental conditions;
- To provide an overview of the work that has been completed to date, including the screening level ERA, baseline ERA problem formulation document, and the preliminary Phase II sampling and analysis plan;
- To present the assessment endpoints that have been established and identify any refinements that are necessary;
- To identify key exposure pathways in the study area;
- To identify key aquatic and terrestrial receptors in the study area; and,
- To select measurement endpoints that will be used to evaluate the status of the assessment endpoints.

4.0 Workshop Summary

The BERA workshop was convened in Lake Charles, LA on September 6 and 7, 2000. To advance workshop goals and objectives, workshop participants (see *Appendix 1* for a list of participants) were asked to articulate ecosystem goals and objectives for the Calcasieu Estuary, to provide input that would assist with the further planning of the remedial investigation/feasibility study (including identification of areas and chemicals of concern, refinement of assessment endpoints, and selection of measurement endpoints), and to assist in the refinement of the Phase II sampling plan. The input that was provided on these topics by workshop participants is summarized in the following sections of this report. The workshop agenda is presented in *Appendix 2*.

4.1 Long-Term Ecosystem Goals and Objectives

Ecosystem goals are broad narrative statements that define the management goals that have been established for a specific ecosystem. Definition of management goals for the aquatic ecosystem is a fundamental step towards the development of defensible management plans for the system. Definition of these ecosystem goals requires input from a number of sources to ensure that societal values are adequately represented. Open consultation with the public should be considered a primary source of information for defining these goals. Government agencies, non-government agencies, and other stakeholders may also be consulted during this phase of the process. Specifically, information on the existing and potential uses of the aquatic resources within the basin should be solicited.

Protection and restoration of natural resources has been identified as an important long-term management goal in the Calcasieu Estuary. However, this goal is too general to support the development of meaningful planning, research, and management initiatives for the area. To be useful, this ecosystem goal must be further clarified and refined to establish ***ecosystem objectives*** that are more closely linked with ecosystem science (Harris *et al.* 1987). In turn, the ecosystem objectives support the identification of indicators and metrics that provide direct information for assessing the health and integrity of the ecosystem.

Workshop participants recognized the importance of establishing ecosystem objectives for the Calcasieu Estuary. The following ecosystem objectives were identified at the workshop to support the RI/FS and the associated baseline ecological risk assessment in the study area:

- Protect and, if necessary, restore benthic conditions that will support a healthy and diverse benthic community;
- Maintain and, if necessary, restore aquatic environmental conditions that will support a healthy and diverse fish community;
- Maintain and, if necessary, restore aquatic, wetland, and terrestrial habitats that will support healthy, diverse, and self-sustaining populations of aquatic dependent avian species;
- Maintain and, if necessary, restore aquatic, wetland, and terrestrial habitats that will support healthy, diverse, and self-sustaining populations of aquatic dependent mammalian species;

- Maintain and, if necessary, restore the productivity of the ecosystem, which supports all other uses of the ecosystem;
- Maintain and, where necessary, restore aquatic habitats;
- Restore any threatened or endangered species that were historically present in the assessment area (e.g., paddlefish; bald eagles; various turtle species);
- Reduce or eliminate fish consumption advisories;
- Maintain and restore commercial fisheries within the Calcasieu Estuary (e.g., shrimp, catfish, crabs); and,
- Restore other human uses of the Calcasieu Estuary, including primary contact recreation (i.e., swimming) and secondary contact recreation (i.e., boating).

4.2 Goals and Objectives of the Remedial Investigation and Feasibility Study

A remedial investigation and feasibility study (FI/FS) has been initiated as part of the Calcasieu Estuary Initiative. Ths RI/FS is an analytical process that is designed to support risk management decision-making at contaminated sites. The remedial investigation component of the RI/FS is intended to provide the information needed to characterize the nature and extent of contamination at the site and to estimate risks to human health and the environment that are posed by contaminants at the site. Such risks are evaluated by conducting human health and ecological risk assessments at the site. The feasibility study component of the RI/FS is intended to support the evaluation of remedial options that can be applied to manage any risks that are identified at the site.

Ecological risk assessments represent essential components of the overall RI/FS process. In accordance with the guidance that has been developed by USEPA (1997), two types of ERAs are typically conducted in the course of implementing a RI/FS. The screening-level ecological risk assessment (SERA) is conducted first and is designed to provide the information needed to determine if ecological risks are likely to occur at the site. If the results of the SERA indicate that ecological threats at the site are negligible, then no further investigations are required to support decision-making activities. In contrast, a baseline ecological risk assessment (BERA) is needed if the results of the SERA indicate that

insufficient information exists to determine if a risk exists or that the potential for adverse ecological effects exists at the site.

In the Calcasieu Estuary, the results of the SERA indicated that there is potential for risk to ecological receptors from exposure to contaminated water and sediment (CDM 1999). As such, it was recommended that the remedial investigation proceed to the initiation of a BERA (CDM 1999). Workshop participants recognized that each of the participants in the ERA process has specific needs that must be met during the course of implementing the BERA. To increase the likelihood that these needs will be met during the remedial investigation, each of the workshop participants was asked to reflect on their organization's interests and needs and to refine the goals and objectives for the project. The input that was provided by workshop participants included:

- Establish and maintain an open, transparent process that provides opportunities for participation by regulated interests and the public;
- Communicate effectively with the public such that people fully understand the issues, appreciate the scope of the problems within the study area, and recognize that many areas do not pose a risk to public health, welfare, and the environment;
- Build a process that is scientifically-defensible;
- Identify the sources and pathways of contaminants to the aquatic systems;
- Determine if adverse effects on aquatic organisms are occurring as a result of exposure to contaminants;
- Determine if adverse effects are associated with contaminated sediments (i.e., the risks to aquatic organisms and aquatic-dependent wildlife);
- Formalize the screening process that has been used to identify the chemicals of potential concern (COPCs; i.e., roughly 25 substances);
- Identify the areas within the study area that represent problems with respect to environmental contamination;
- Identify the areas within the study area that do not represent problems with respect to environmental contamination;
- Develop remediation goals that will protect wildlife;
- Develop scientifically-defensible clean-up targets for each habitat type and environmental medium;

- Build cooperative solutions to the problems that exist in the study area;
- Generate information on recovery times for the no action remedial option (i.e., using modeling efforts based on sedimentation rates; focus on key areas such as Bayou d'Inde; note: natural recovery must occur within a reasonable time frame to represent a viable option);
- Develop a rationale for action and remedial alternatives that the public will understand and support; and,
- Identify the long-term monitoring that is needed to evaluate recovery in the study area and restoration of the uses of the ecosystem.

4.3 Planning for a Baseline Ecological Risk Assessment

The BERA process consists of three main steps including problem formulation, exposure and risk analysis (i.e., characterization of exposure and characterization of ecological effects), and risk characterization. As the first step in the BERA process, the problem formulation process establishes the goals, breadth, and focus of the BERA. Some of the important activities that need to be completed during the problem formulation process include (USEPA 1997):

- Refinement of the preliminary list of contaminants of ecological concern (i.e., the COPCs);
- Further characterization of the ecological effects of the COPCs;
- Review and refinement of the information on contaminant fate and transport, exposure pathways, and receptors at risk;
- Selection of assessment endpoints;
- Development of conceptual models and associated working hypotheses that the site investigation will address; and,
- Selection of measurement endpoints that provide the information needed to evaluate the status of the assessment endpoints.

This step of the BERA culminates in a scientific management decision point (SMDP), at which the risk assessors and the risk managers agree on the assessment endpoints, exposure pathways, and the questions as portrayed in the conceptual model of the site (USEPA 1997). The problem formulation process for the Calcasieu Estuary BERA was initiated by CDM Federal in early 2000 and has progressed to approximately 50% completion (CDM 2000). However, it is unlikely that the problem formulation document will be completed in time to support the design of the Phase II sampling program. For this reason, this workshop was designed to facilitate preliminary problem formulation for the BERA. In this way, the Phase II sampling program can be designed and implemented with a clear understanding of the potential problems that exist at the site. In a parallel effort, the detailed problem formulation document can be developed at a pace that would assure its scientific-defensibility. The following sections of this report are intended to document the results of the discussions on problem formulation for the Calcasieu Estuary BERA.

4.3.1 Identification of Chemicals and Areas of Potential Concern

The identification of chemicals and areas of potential concern represents an essential element of the problem formulation process. To support the development of a preliminary problem formulation the workshop participants reviewed the results of the SERA, recalled the results of a scoping meeting that was convened in Denver, CO in July, 2000 (the scoping meeting was attended by the risk assessors, the risk managers, and the USEPA Region VI Ecological Technical Assistance Group; ETAG), and conducted further evaluations using the data that were generated in the Phase I sampling program.

A consistent approach was used to identify the chemicals of potential concern in the Calcasieu Estuary. For water-borne constituents, the substances that occurred in water samples at concentrations (i.e., total concentrations in unfiltered water samples) in excess of the ambient water quality criteria (i.e., final chronic value) were considered to be COPCs. For sediment-associated constituents, the substances that occurred in whole sediments at concentrations in excess of the effects range median (ERMs; Long *et al.* 1995) or comparable sediment quality benchmarks (i.e., probable effect levels; MacDonald *et al.* 1996; CCME 1999) were considered to be COPCs. Based on the results of these evaluations, the workshop participants agreed that the following substances were the primary COPCs in the Calcasieu Estuary:

Water-Borne COPCs

- metals (Cu and Hg);
- 1,2-dichloroethane (DCE); and,
- trichloroethane (TCA)

Sediment-Associated COPCs

- metals (Cu, Cr, Pb, Hg, Ni, and Zn);
- polycyclic aromatic hydrocarbons (PAHs; acenaphthene, acenaphthylene, anthracene, fluorene, 2-methylnaphthalene, naphthalene, phenanthrene, benz[a]anthracene, benzo(a)pyrene, chrysene, dibenz[a,h]anthracene, fluoranthene, pyrene, total PAHs, and other PAHs);
- polychlorinated biphenyls (PCBs);
- polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)
- chlorinated benzenes (hexachlorobenzene; HCB, hexachlorobutadiene; BCBD, and degradation products);
- bis(2-ethylhexyl)phthalate (BEHP);
- 1,2-dichloroethane (DCE);
- trichloroethane (TCA);
- carbon disulfide;
- acetone; and,
- organochlorine pesticides (aldrin and dieldrin).

The areas of concern with respect to environmental contamination were identified using an approach that was similar to the one that was used to identify the COPCs. More specifically, the areas in which concentrations of one or more sediment-associated substances exceeded the ERM or a comparable benchmark were considered to be areas of concern. The areas of concern that were identified by workshop participants included:

- Lower Bayou Verdine (i.e., downstream of the west ditch; COPCs included Cr, Cu, Zn, PAHs, and DCA);
- Upper Bayou Verdine (i.e., upstream of the west ditch; COPCs included PAHs);
- Clooney Island Loop (COPCs included PAHs);
- Clooney Island Loop Barge Slip (COPCs included Cr, Zn, and PCBs);
- Coon Island Loop Northeast (COPCs included PAHs and PCBs);

- Coon Island Loop Southwest (COPCs included PAHs);
- Lower Bayou d'Inde (i.e., mouth to the first bridge over the bayou, including the PPG canal; COPCs included Cu, Cr, Pb, Hg, Ni, Zn, PAHs, PCBs, PCDDs/PCDFs, HCB, HCBD, acetone, aldrin, and dieldrin);
- Middle Bayou d'Inde (COPCs included Ni, Pb, and PCBs);
- South Prien Lake (COPCs included BEHP); and,
- Citgo Surge Pond Outflow (COPCs included Cu, Pb, Hg, PAHs, and PCBs).

To facilitate the development of conceptual models that link stressors to receptors, the COPCs were classified into three groups based on their fate and effects in the aquatic ecosystem, including bioaccumulative substances, toxic substances that partition into sediments, and toxic substances that partition into water. The COPCs were classified as follows:

Bioaccumulative Substances

- metals (Hg);
- polycyclic aromatic hydrocarbons (PAHs; acenaphthene, acenaphthylene, anthracene, fluorene, 2-methylnaphthalene, naphthalene, phenanthrene, benz[a]anthracene, benzo(a)pyrene, chrysene, dibenz[a,h]anthracene, fluoranthene, pyrene, total PAHs, and other PAHs);
- PCBs;
- polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)
- chlorinated benzenes [hexachlorobenzene (HCB), hexachlorobutadienes (HCBD), and degradation products]; and,
- organochlorine pesticides (aldrin and dieldrin).

Toxic Substances that Partition into Sediments

- metals (Cu, Cr, Pb, Hg, Ni, and Zn);
- PAHs (acenaphthene, acenaphthylene, anthracene, fluorene, 2-methylnaphthalene, naphthalene, phenanthrene, benz[a]anthracene, benzo(a)pyrene, chrysene, dibenz[a,h]anthracene, fluoranthene, pyrene, total PAHs, and other PAHs);
- PCBs;
- chlorinated benzenes (HCB, HCBD, and degradation products);

- BEHP;
- organochlorine pesticides (aldrin and dieldrin);
- unionized ammonia (NH_3); and,
- hydrogen sulfide (H_2S).

Toxic Substances that Partition into Water

- metals (Cu and Hg)
- 1,2-dichloroethane (DCE); and,
- trichloroethane (TCA).

Substances that Partition into the Surface Microlayer

- metals;
- volatile organic chemicals; and,
- semi-volatile organic chemicals.

4.3.2 Refinement of Assessment Endpoints

An assessment endpoint is defined as an 'explicit expression of the environmental value that is to be protected' (USEPA 1997). In the environment, a variety of species are likely to be exposed to COPCs. Each of these receptors may be exposed to a chemical via slightly different exposure routes and have the potential to exhibit different types and severity of effects. While information on the effects of each chemical on each component of the ecosystem would provide comprehensive information for evaluating ecological risks, it is neither practical nor possible to directly evaluate risks to all of the individual components of the ecosystem at a site (USEPA 1997). For this reason, the assessment endpoints are intended to focus the risk assessment on the particular components of the ecosystem that are most likely to be adversely affected by the presence of environmental contaminants at the site.

Assessment endpoints for a baseline ecological risk assessment must be selected based on the ecosystems, communities, and species that occur, have historically occurred, or could potentially occur at the site (USEPA 1997). According to the USEPA (1997), the selection of assessment endpoints depends on:

- The contaminants present and their concentrations;

- Mechanisms of toxicity of the contaminants to different groups of organisms;
- Ecologically-relevant receptor groups that are potentially sensitive or highly exposed to the contaminant and attributes of their natural history; and,
- Potentially complete exposure pathways.

Thus, the risk assessment team must think through the mechanisms of ecotoxicity for each contaminant or group of contaminants to determine which receptors are likely to be most at risk. This information must include an understanding of how the adverse effects of the contaminant could be expressed (e.g., eggshell thinning in birds) and of how the form of the chemical in the environment could influence its bioavailability and toxicity.

As part of the preliminary problem formulation, a number of candidate assessment endpoints were identified for use in the Calcasieu Estuary BERA (CDM 2000). The preliminary list of assessment endpoints included:

- Survival and growth of benthic invertebrates;
- Survival, growth, and reproduction of fish;
- Survival and reproduction of invertebrate-eating, sediment-probing birds;
- Survival and reproduction of carnivorous or piscivorus wading birds;
- Survival and reproduction of piscivorus birds; and,
- Survival and reproduction of piscivorus mammals.

The workshop participants reviewed the list of candidate assessment endpoints and concluded that it included many of the receptors of potential concern in the study area. However, the list did not include some of the receptors that could, potentially, be adversely affected by environmental contamination (i.e., primary productivity, pelagic invertebrates, amphibians, reptiles, insectivorous birds, omnivorous mammals, and carnivorous mammals). In addition, the candidate assessment endpoints that were identified previously had not been linked directly to the specific chemicals or chemical classes for which they were most applicable. For this reason, workshop participants decided to re-evaluate the candidate assessment endpoints based on the three categories of COPCs that were identified previously (see Section 4.3.1).

Workshop participants recognized that routes of exposure and mechanisms of toxicity differ for the various COPCs that occur in the Calcasieu Estuary. For this reason, the COPCs were separated into four groups, based on their mode of action and likely environmental fate (see Section 4.3.1). For the first group of COPCs, bioaccumulative substances, a total of ten groups of receptors were identified, including benthic invertebrates, carnivorous fish, reptiles, amphibians, insectivorous birds, sediment-probing birds, carnivorous wading birds, other piscivorus birds, and piscivorus mammals (*Table 1*). For each of these groups of receptors, the workshop participants identified assessment endpoints, focal species, and candidate measurement endpoints. Likewise, receptor groups, assessment endpoints, focal species, and candidate measurement endpoints were identified for the toxic substances that are likely to partition into sediments (*Table 2*), the toxic substances that are likely to partition into overlying water (*Table 3*), and the substances that are likely to occur in the surface microlayer (*Table 4*). The generalized food web model for Gulf Coast estuaries (*Figure 1*; TNRCC 2000) was used to support the evaluation of linkages between stressors and receptors in the study area. Collectively, the information in these tables provides an extensive suite of candidate measurement endpoints that can be used to support the selection of priority measurement endpoints for the Calcasieu Estuary.

4.3.3 Selection of Priority Measurement Endpoints

A measurement endpoint is defined as 'a measurable ecological characteristic that is related to the valued characteristic that is selected as the assessment endpoint' and it is a measure of biological effects (e.g., mortality, reproduction, growth; USEPA 1997). Measurement endpoints are frequently numerical expressions of observations (e.g., toxicity test results, community diversity measures) that can be compared to similar observations at a control or reference site. Such statistical comparisons provide a basis for evaluating the effects that are associated with exposure to a contaminant or group of contaminants at the site under consideration. Measure endpoints can include measures of exposure (e.g., contaminant concentrations in water or sediments) or measures of effects (e.g., survival or growth of amphipods in 10-d toxicity tests). The relationship between an assessment endpoint and a measurement endpoint must be clearly described within the conceptual model and must be based on scientific evidence (USEPA 1997).

After identifying receptors of concern and candidate assessment endpoints, the workshop participants described the linkages that are likely to exist between exposure media (i.e., stressors) and receptors within the Calcasieu Estuary. The results of this process enabled workshop participants to identify focal species for each group of receptors and each group of chemical substances. In turn, this information was used to identify candidate measurement endpoints that could be used to evaluate the status of each assessment endpoint (*Table 1 to 4*). Workshop participants recognized that it would not be practical nor possible to incorporate all of the candidate measurement endpoints into the remedial investigation. For this reason, each workshop participant were asked to identify five candidate measurement endpoints that would provide the most useful information for evaluating the ecological risks associated with exposure to environmental contaminants in the study area. Subsequently, this input was compiled and used to identify the highest priority measurement endpoints for inclusion in the remedial investigation (i.e., the Phase II sampling program). Based on the input that was provided by workshop participants, the highest priority measurement endpoints are (the number of individuals who selected each measurement endpoint is shown in parentheses):

Bioaccumulative Substances:

Assessment Endpoint - Survival and growth of benthic invertebrates:

- The concentrations of bioaccumulative substances in epibenthic and infaunal invertebrate species, including crabs, shrimp, and bivalves (2).

Assessment Endpoint - Survival, growth, and reproduction of carnivorous fish:

- The concentrations of bioaccumulative substances in the tissues of prey species of carnivorous fish, including both forage fish and invertebrates (6);
- The concentrations of bioaccumulative substances and biomarkers in carnivorous fish (3); and,
- Fecundity of killifish (1).

Assessment Endpoint - Survival and reproduction of insectivorous birds:

- The concentrations of bioaccumulative substances in the tissues of prey species of birds (7); and,
- The reproductive success of insectivorous bird (e.g., swallows) and sediment-probing birds (e.g., stilts; 2).

Assessment Endpoint - Survival and reproduction of sediment-probing birds:

- The concentrations of bioaccumulative substances in the tissues of prey species of sediment-probing birds (i.e., in benthic macroinvertebrates; 7).

Assessment Endpoint - Survival and reproduction of carnivorous wading birds:

- The concentrations of bioaccumulative substances in the tissues of prey species of carnivorous wading birds (i.e., fish, amphibians, reptiles, etc.; 7).

Assessment Endpoint - Survival and reproduction of other piscivorus birds:

- The concentrations of bioaccumulative substances in the tissues of prey species of other piscivorus birds (7).

Assessment Endpoint - Survival and reproduction of piscivorus mammals:

- The concentrations of bioaccumulative substances in the tissues of prey species of piscivorus mammals (3);
- The concentrations of bioaccumulative substances in the raccoon tissues (1); and,
- The presence/absence of sensitive mammalian species (e.g., mink) in habitats that are likely to support those species (1).

Toxic Substances that Partition into Sediments

Assessment Endpoint - Survival and growth of benthic invertebrates:

- The concentrations of toxic substances in sediments (4);
- The concentrations of toxic substances in pore water (2);
- The results of acute toxicity tests with whole sediments and pore water (8);
- The results of chronic toxicity tests with whole sediments and pore water (8); and,
- The results of benthic invertebrate community assessments (6).

Assessment Endpoint - Survival, growth, and reproduction of benthic fish:

- The results of toxicity tests with killifish or silversides (5); and,
- The presence/absence, distribution, and abundance of benthic fish (5).

Toxic Substances that Partition into Water

No measurement endpoints were identified as priorities for inclusion in the remedial investigation.

Toxic Substances that Partition into the Surface Microlayer

Assessment Endpoint - Survival, growth, and reproduction of pelagic fish:

- The incidence of DELT abnormalities (including deformities, fin erosion, lesions, and tumors) in menhaden (1).

4.4 Refinement of the Phase II Sampling Program Design

The workshop participants recognized that the Phase II sampling program for the remedial investigation will provide essential information for evaluating the ecological risks associated with exposure to environmental contaminants in the Calcasieu Estuary. Based on the input that was provided by workshop participants, it is apparent that the Phase II sampling program should be designed to provide information on exposure and effects on sediment-dwelling organisms, fish, birds, and mammals. The key types of data that are needed include sediment chemistry, sediment toxicity (invertebrates and fish), pore water toxicity, benthic invertebrate community structure, tissue chemistry (invertebrates and fish), and fish community status.

After identifying key information requirements to support the ecological risk assessment, workshop participants also developed a number of preliminary recommendations regarding the Phase II sampling program, including:

- **Fish community surveys** - Workshop participants agreed that a survey of the distribution and abundance of fish in the Calcasieu Estuary would provide a snapshot of present conditions only. For this reason, it was suggested that a survey of the fish community could be designed to determine the presence/absence of sensitive species, to facilitate comparisons between areas (rather than over time) and expectations. It was also suggested that the condition of fish and the percent incidence of DELT abnormalities could be determined for

each area. Furthermore, it was suggested that this information could be collected in concert with the tissue residue survey to enhance efficiency. However, workshop participants also recognized that one survey would provide incomplete information for assessing the status of the fish community. Therefore, it was agreed that the fish community survey should be considered to be a lower priority than some of the other components of the remedial investigation;

- **Fish toxicity tests** - Workshop participants recognized that it is difficult to identify sediment toxicity tests with fish that would be more sensitive than the invertebrate tests. Nevertheless, it was noted that the pore water toxicity tests with embryo-larval stage of red drum would provide useful information for assessing toxicity to fish;

- **Tissue chemistry** - Workshop participants indicated that information on the concentrations of COPCs in the tissues of fish and invertebrates was essential for evaluating risks to carnivorous fish, birds, and mammals. While some tissue chemistry data are currently available, more data will be required to fully evaluate risks to aquatic and terrestrial receptors. The key locations for conducting fish and invertebrate tissue sampling included lower Bayou d'Inde, Clooney Island loop and barge slip, Coon Island loop, and the Citgo surge pond area. It was noted that each of the focal species are likely to have different dietary exposure patterns, depending on the type and size (i.e., age) of the prey species that are consumed, the location of the foraging areas that are utilized, and various other factors. For this reason, it was suggested that the life histories and dietary requirements of the focal species be further evaluated to support refinement of the Phase II sampling program. It was also noted that, while it would be difficult to obtain tissue samples for many invertebrate species, it should be possible to obtain samples of bivalve (*Rangia sp.*) and crab tissues. In addition, it may be possible to obtain samples of invertebrate tissues from fish stomachs that could be used to conduct tissue residue analyses;

- **Sediment quality triad** - Workshop participants recognized that three types of data were needed to effectively evaluate risks to sediment-dwelling organisms, including sediment chemistry, sediment toxicity, and benthic invertebrate community structure. In addition to providing the information needed to evaluate the ecological risks that are associated with contaminated sediments,

synoptically-collected data for the sediment quality triad are needed to confirm the predictive ability of the sediment quality guidelines. The design and implementation of the sediment quality triad investigation was identified as a high priority by workshop participants;

- **Bioaccumulation assessment** - Workshop participants noted that bioaccumulation of sediment-associated contaminants has the potential to adversely affect a variety of ecological receptors, including fish, birds, and mammals. Three approaches to the assessment of bioaccumulation potential were identified, including laboratory bioaccumulation tests (i.e., using polychaetes or oligochaetes), deployment of semi-permeable membrane devices (SPMDs), and caged bivalve experiments.

In addition to these primary information needs, workshop participants also indicated that some additional sampling effort may be required to complete the eco-characterization of the study area. It was also noted that the results of the Phase II sampling program should provide the information needed to fully validate the areas of concern and the areas that are currently considered to be of relatively lower priority. Furthermore, workshop participants indicated that the sampling program should be designed to provide a weight-of-evidence for evaluating risks to aquatic organisms and to aquatic-dependent birds and mammals.

5.0 Conclusions and Recommendations

A workshop was convened to refine the approach that will be used to conduct the baseline ecological risk assessment for the Calcasieu Estuary. As such, the results of this workshop provide important information that can and should be used to guide the remedial investigation in the near-term and to support ERA in the longer-term. Workshop participants agreed that a great deal of information has already been collected that will support the BERA. Importantly, workshop participants also agreed that the assessment and measurement endpoints that were identified during the workshop provide a basis for designing a scientific-defensible sampling program (i.e., Phase II sampling program) to obtain the data that are needed to complete the BERA. However, it was recognized that it will be necessary to complete the problem formulation document to corroborate the decisions that were made at

the workshop, to formalize the problem formulation step of the ERA process, and to identify any outstanding information requirements that might exist following the completion of the Phase II sampling program. Some of the tasks that need to be completed in the near-term to support the remedial investigation/feasibility study include:

- Complete the first draft of the workshop summary report;
- Distribute the draft workshop summary report to workshop participants for review and comment;
- Incorporate reviewers' comments into the draft workshop summary report;
- Provide the public with access to the draft workshop summary report and solicit comments;
- Distribute the draft Phase II sampling plan, including the associated data quality objectives, to workshop participants for review and comment;
- Refine the draft Phase II sampling plan based on the comments provided by workshop participants;
- Provide the public with access to the Phase II sampling plan;
- Design a sediment quality triad investigation that will support the ecological risk assessment;
- Distribute the draft sediment quality triad study plan to workshop participants for review and comment;
- Refine the draft sediment quality triad study plan based on the comments provided by workshop participants; and,
- Provide the public with access to the sediment quality triad study plan.

In addition to the proceeding tasks, it was agreed that work on the problem formulation document and the other steps of the BERA should proceed in a timely manner to support early action in the Calcasieu Estuary.

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Appendix 2. Workshop Agenda and Schedule

Calcasieu Estuary Remedial Investigation/Feasibility Study (RI/FS):
Baseline Ecological Risk Assessment Workshop

September 6 - 8, 2000

Calcasieu Outreach Office
110 West Prien Lake Road
Lake Charles, Louisiana 70601

1.0 Workshop Agenda and Schedule

The site reconnaissance and baseline ecological risk assessment workshop will be convened during September 6 - 8, 2000. The agenda and schedule for the meeting is as follows:

September 6, 2000

7:30 - 12:00 Site reconnaissance of the Calcasieu Estuary (the reconnaissance will also provide an opportunity to introduce the MacDonald Environmental Sciences Ltd. team to the existing study team and share information on interests and concerns).

12:00- 13:00 Lunch

13:00 - 17:00 Information Exchange Session; This session will include informal presentations and Q&A on the following topics:

- overall project strategy;
- locations of facilities;
- chemicals of concern (by facility and reach);
- locations of sediment hot spots;
- ecology of the study area;
- ambient environmental conditions;
- public participation and input;
- results of the screening level ERA;
- status of the baseline ERA problem formulation document; and,
- status of the preliminary Phase II sampling and analysis plan.

September 7, 2000

08:00 - 10:00 Information Exchange Session, continued

10:00 - 12:00 Work Group Session - Problem Formulation; This session will focus on the development of measurement endpoints for the BERA and include:

- presentation on the assessment endpoints that have been established;
- identification of any refinements to the assessment endpoints that are necessary; and,
- round table discussion on measurement endpoints.

12:00 - 13:00 Lunch

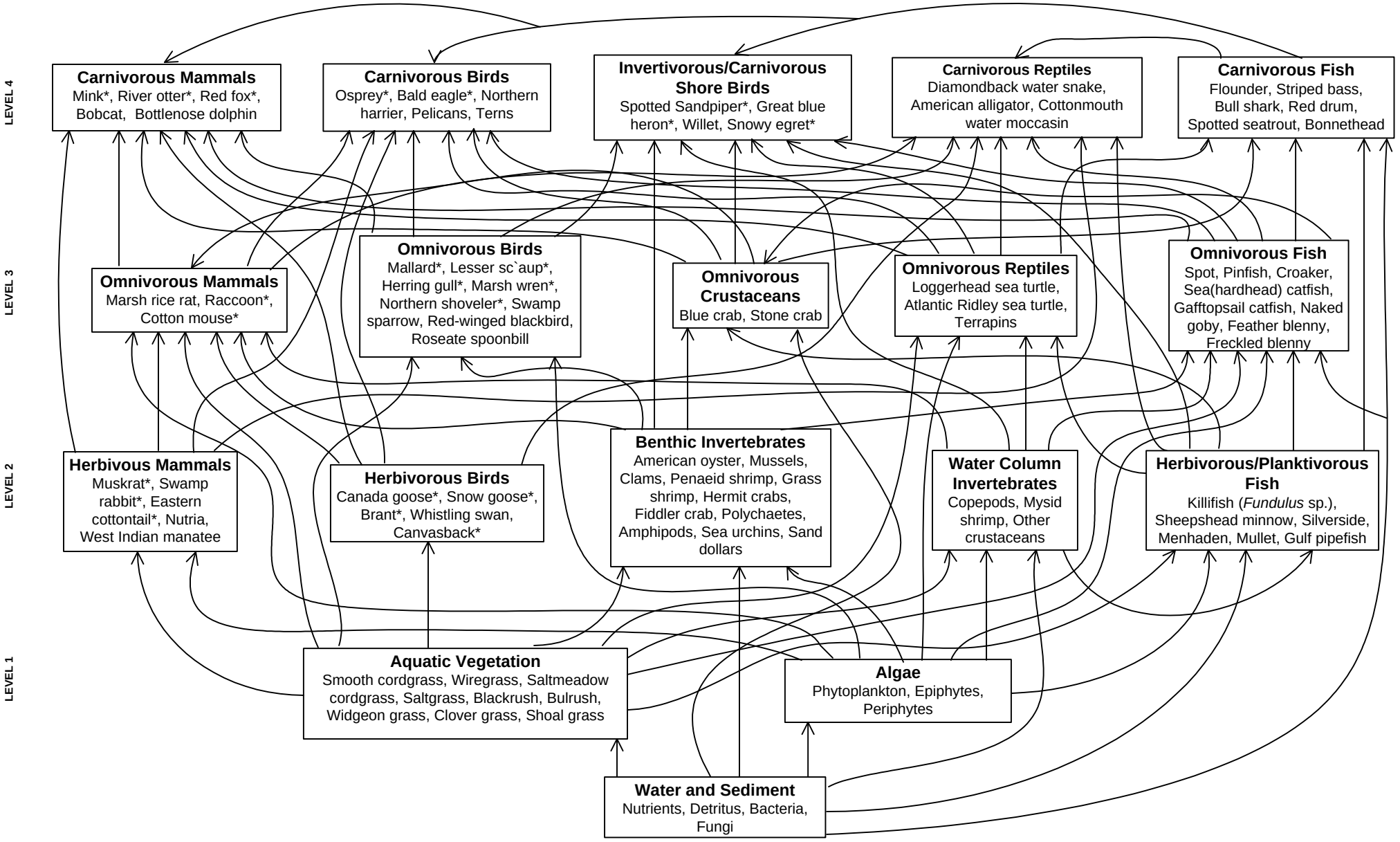
13:00 - 17:00 Work Group Session - Problem Formulation

- Round table discussion on measurement endpoints

September 8, 2000

08:00 - 11:00 Work Group Session - Strategy Meeting with Study Team to develop work plan, identify deliverables, and refine schedule.

FIGURE 1
EXAMPLE GULF COAST
ESTUARINE FOOD WEB (TNRCC 2000)



* Receptors with an asterisk are species (or closely related species) found in U.S. EPA's WIldlife Exposure Factors Handbook (1993)

Table 1. Ecological Assessment and Measurement Endpoints for Bioaccumulative Substances.

Receptor	Assessment Endpoint	Focal Species	Candidate Measurement Endpoints
Benthic Invertebrates	Survival and Growth	blue crabs, bivalves (*Rangia sp.*), other crabs	Contaminant levels in tissues of crabs, bivalves, shrimp. Abundance and distribution of focal species. Contaminant levels in tissues of prey species.
Carnivorous Fish	Survival, Growth, and Reproduction	redfish (benthic feeder), black drum (mollusc and sediment ingestion), seatrout (pelagic feeder), flounder (pelagic feeder), gar (pelagic feeder)	Fish community status (creel or targeted surveys) Contaminant levels in tissues of prey species. Contaminant levels in tissues of carnivorous fish. Fecundity (i.e., in killifish). Fish health (% incidence of DELT abnormalities). Contaminant accumulation rates (feeding trials).
Reptiles	Survival, Growth, and Reproduction	alligators, snapping turtles, snakes	Penis size in turtles.
Amphibians	Survival, Growth, and Reproduction	bull frogs, leopard frogs, pig frogs	None suggested
Insectivorous Birds	Survival and Reproduction	Swallows, purple martins	Tissue residues and biomarkers in eggs and other tissues. Reproductive success. Developmental abnormalities.
Sediment-Probing Birds	Survival and Reproduction	sandpipers, willet, spoonbills, stilts, ibis, ducks	Contaminant levels in tissues of prey species. Tissue residues and biomarkers in eggs and other tissues. Behavioral abnormalities Accumulation rates and effects in feeding trials.

Table 1. Ecological Assessment and Measurement Endpoints for Bioaccumulative Substances.

Receptor	Assessment Endpoint	Focal Species	Candidate Measurement Endpoints
Carnivorous Wading Birds	Survival and Reproduction	great blue heron, great egret	Contaminant levels in tissues of prey species. Tissue residues and biomarkers in eggs and other tissues. Behavioral abnormalities Reproductive success. Developmental abnormalities.
Piscivorous Birds	Survival and Reproduction	osprey (feed on large fish), kingfisher (feed on small fish), pelicans (concentrate at mouth of Bayou d'Inde), terns	Contaminant levels in tissues of prey species. Tissue residues and biomarkers in eggs and other tissues. Behavioral abnormalities Reproductive success. Developmental abnormalities.
Piscivorous Mammals	Survival and Reproduction	Dolphins, river otter, mink, raccoons	Contaminant levels in tissues of prey species. Tissue residue levels in raccoon tissues. Presence/absence of sensitive species (i.e., in habitats that would be expected to support those species).

Table 2. Ecological Assessment and Measurement Endpoints for Toxic Substances that Partition into Sediments.

Receptor	Assessment Endpoint	Focal Species	Candidate Measurement Endpoints
Decomposers	Processing of Organic Carbon	Bacteria	Metabolic rate of bacteria (using Microtox as surrogate) Ammonia production rate. Changes on functional groups (Burton and Stemmer 1988) Porewater chemistry compared to toxicity thresholds.
Aquatic plants	Survival and growth	rooted aquatic plants (*Spartina)* and other macrophytes, algae	Surival and growth of indicator species (acute toxicity tests). Sediment chemistry compared to toxicity thresholds. Comparison of sensitivity of plants to invertebrates in water-only toxicity tests. Distribution and abundance of aquatic plants (salinity and others could be confounding factors).
Benthic Invertebrates	Survival and Growth	epifauna - shrimp, crabs infauna - copepods, amphipods	Survival and growth of the amphipod *Hyalella azteca* (10-d WS test). Survival and growth of the amphipod *Hyalella azteca* (28-d WS test). Survival and growth of the amphipod *Ampelisca abdita* (10-d WS test). Fertilization and development of the sea urchin *Arbacia sp* . (PW test) Sediment chemistry compared to SQGs. Porewater chemistry compared to toxicity thresholds. Benthic invertebrate community structure. Sediment quality triad evaluation.
Benthic Fish	Survival, Growth, and Reproduction	redfish (benthic feeder), black drum (mollusc and sediment ingestion), flounder (pelagic feeder), gobis, blennies, killifish	Fish community status (creel or targeted surveys) Sediment chemistry compared to SQGs. Biomarkers in carnivorous fish tissues. Fecundity (i.e., in killifish). Fish health (% incidence of DELT abnormalities)[1]. Survival, development, growth in killifish or silversides (embryo-larval toxicity tests)

Table 2. Ecological Assessment and Measurement Endpoints for Toxic Substances that Partition into Sediments.

Receptor	Assessment Endpoint	Focal Species	Candidate Measurement Endpoints
Reptiles	Survival, Growth, and Reproduction	alligators, snapping turtles, snakes	None suggested
Amphibians	Survival, Growth, and Reproduction	bull frogs, leopard frogs, pig frogs	Survival and growth of frogs (acute toxicity tests) Sediment chemistry compared to SQGs.
Sediment-Probing Birds	Survival and Reproduction	sandpipers, willet, spoonbills, stilts, idis, ducks	Sediment chemistry compared to SQGs. Tissue chemistry in prey.

[1]DELT = deformaties, fin erosion, lesions, and tumors.

Table 3. Ecological Assessment and Measurement Endpoints for Toxic Substances that Partition into Overlying Water.

Receptor	Assessment Endpoint	Focal Species	Candidate Measurement Endpoints
Aquatic plants	Survival and growth	rooted aquatic plants (*Spartina)* and other macrophytes, algae	Surival and growth of indicator species (acute toxicity tests). Sediment chemistry compared to toxicity thresholds. Comparison of sensitivity of plants to invertebrates in water-only toxicity tests. Distribution and abundance of aquatic plants (salinity and others could be confounding factors).
Aquatic Invertebrates	Survival and Growth	epibenthic species, such as shrimp and crabs	Survival and growth of indicator species (acute toxicity test) Water chemistry compared to toxicity thresholds.
Benthic Fish	Survival, Growth, and Reproduction	redfish, black drum, seatrout, flounder, gar, croaker, gobis, blennies, killifish	Survival and growth of indicator species (acute toxicity test) Water chemistry compared to toxicity thresholds. Fish health (% incidence of DELT abnormalities)[1].

[1]DELT = deformaties, fin erosion, lesions, and tumors.

Table 4. Ecological Assessment and Measurement Endpoints for Toxic Substances that Partition into the Surface Microlayer.

Receptor	Assessment Endpoint	Focal Species	Candidate Measurement Endpoints
Invertebrates	Survival and Growth	decapod larvae, water striders, mosquito larvae	Survival and growth of indicator species (acute toxicity test) Water chemistry compared to toxicity thresholds.
Pelagic Fish	Survival, Growth, and Reproduction	Menhaden, seatrout egg (which float)	Survival and growth of indicator species (acute toxicity test) Water chemistry compared to toxicity thresholds. Fish health (% incidence of DELT abnormalities)[1].

[1]DELT = deformaties, fin erosion, lesions, and tumors.